FIG. 7 is a flow diagram of the crosswise scale process.

FIG. 8A is a diagram of the translation of the crosswise scaled pixels to the chosen resolution pixels in the lengthwise scale process.

FIG. 8B is a flow diagram of the lengthwise scale process.

FIG. 9A is a diagram illustrating how an image and associated reference tracks are distorted in the scanning process.

FIG. 9B is a diagram of the reference tracks and the film during the crosswise scale process.

FIG. 9C is a representation of the reference tracks and the film during the lengthwise scale process.

FIG. 10A is a detailed drawing of an embodiment of the reference tracks using a single clock track.

FIG. 10B is a detailed drawing of a preferred embodiment of the reference tracks using a gray code track.

FIG. 10C shows the relation of the reference tracks to the lights, film holder, and optics.

FIG. 11 portrays the origin of aliases caused by digitally sampling a continuous signal.

FIG. 12A maps the mirroring of aliases around the Nyquist frequency from higher frequencies back to lower frequencies caused by digitally sampling a continuous signal.

FIG. 12B maps the mirroring of aliases around the Nyquist frequency from lower frequencies to higher frequencies caused by reforming a digitally sampled signal into a continuous signal.

FIG. 13 maps the multiple mirroring at aliases caused by digitally sampling at a first resolution, and then resizing that digitally sampled signal to a second resolution.

FIG. 14A portrays common filter impulse responses both in the spatial domain and in the spatial frequency domain.

FIG. 14B shows the effect of applying the impulse responses of FIG. 14A to a sinusoidal signal.

FIG. 14C illustrates the mathematical origin of the shape of a "sinc" filter.

FIG. 14D illustrates the effect of limiting the width of a sinc impulse response.

FIG. 15A shows how an image, distorted by speed jitter, lateral jitter, and size jitter as in FIG. 1, can be converted to rectilinear form according to this invention.

FIG. 15B shows the effect similar to that of FIG. 15A relative to the sample grid.

FIG. 16 portrays in one dimension the details of the prescale and precision scaling.

FIGS. 17A, 17B, and 17C show the spatial frequency response and aliases at the different stages of processing portrayed in FIG. 16.

FIGS. 18 and 19A–F illustrate the use of a sinc filter in the image domain.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, a film, 20 or other substrate on which the image is disposed is moved with respect to linear sensor array 21 to scan the image stored therein. The scanned image received by this linear array has a number of errors induced by deficiencies in the transport system. These errors are illustrated by an imaginary grid pattern 22, superimposed over the film 20. For ease of illustration, the film 20 itself is not depicted with those same errors, the errors represent how the array pixels would map back to the fixed film, as though the array were writing the grid pattern onto the fixed film. As the individual sensors are fixed in the silicon of the sensor array 21, some classical distortions are impossible. The distortions which are possible include a varying horizontal magnification 23 caused by speed jitter, a vertical waviness 24 caused by the lateral jitter of the sensor or the film. A complementary vertical waviness 25 is caused by optical magnification variations due to change of focus of the imaging lens or movement of the film toward and away from the imaging lens during a scan, and is called size jitter. Finally, the slanting 26 of vertical lines is caused by a twisting of the array. This twist jitter 26 is not a particularly significant problem in the experience of the applicants.

As shown in FIG. 2A, a scanner 30 is coupled to a personal computer 70, shown in block diagram form in FIG. 2B, by means of a cable 31. A protective housing 32 is provided in which the various electrical, mechanical and optical systems are contained. A strip of film (not pictured) is introduced into the entry aperture 33 and exits from the exit path aperture 34 in the direction of the arrows. After the film strip is urged sufficiently into the entry aperture 33, the drum assembly 35 will grasp the film strip drawing it within the housing 32. The drum assembly 35 rotates around the shaft 36 in the direction of the arrows. As the film strips rotates with the drum assembly 35, the film strip will eventually traverse the semicircular path around the shaft 36.

On the inner surface of the right and left portions of the drum 35, two reference tracks (not pictured) will be imprinted which serve as timing tracks or position locators during the scanning process. These will be discussed in much greater detail below in connection with FIGS. 9–10.

The light source 37, lens assembly 38, transducer scanner assembly 39, and power supply 40 are among the components of the scanner which are controlled by the electronic circuitry 41. The rotational translation of the drum 35 about the axle 36 is accomplished by an electronic motor 42 and drive belt 43 disposed around drum drive wheel 44. After the film is translated to a position opposite light source 37, the image is read along optical path 45 to lens assembly 38 which focuses the image on the transducer/scanner assembly 39. The scanner assembly 39 preferably comprises a CCD linear array such as part number TCD 1300*b* which is available from Toshiba. The reference tracks imprinted on the inner surfaces of the right and left film support shoulders of the drum are also simultaneously scanned by the scanner assembly 39.

Referring to FIG. 2B, the scanner 30 is shown coupled to the computer 70 by means of cable 31 in block diagram architectural form. Items such as a connection to a suitable source of electronic power such as a 110 volt AC line, power switch with appropriate fusing and the power supply for the computer and scanner are not depicted for sake of clarity. The scanner is coupled to the computer by means of I/O interface 47. In the preferred embodiment, a digital signal processor 48 is required for controlling the operation of the various components and for storing the scanning data derived from the operation of the scanner in RAN 49. The components of the scanner are controlled by the computer in alternative embodiments. Address data and control lines extend through the cable 31 to the personal computer 70. The DSP 48 and load storage 49 together provide the appropriate address and command functions to the other components of the scanner.

The DSP 48 may control the color and intensity of lamp 37 shining through the film, the speed and direction of the motor 42 and the scanning of the CCD array 39 through the